A CASK TAILORED TO A NPP NEEDS: THE TN 24 G FOR GÖSGEN, SWITZERLAND

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Introduction

When Kernkraftwerk Gösgen (KKG), Switzerland, specified its needs for a dual purpose cask for spent fuel assemblies, it had to solve a complex equation:

- Dry storage capacity for KKG would rely on Zwilag, the centralized interim storage facility created jointly by the four Swiss operators of NPP and would therefore have to comply with the storage specifications,
- KKG wished to keep its options open with respect to sending its spent fuel to reprocessing,
- KKG wished to minimize dose to operators and transport operations,
- As any NPP, KKG had to take into account its limitations in lifting capacity and in operating space for cask loading at the NPP.

The specification it produced gave a tentative list of spent fuel assemblies that were to be loaded in the casks, complete with irradiation data and a drawing of the loading pool and access funnel.

The TN 24 cask family

When Transnucléaire received the request for proposal, it was clear that such current members of the TN 24 cask family (see table 1) as the TN 24 XL could fit the requirements, but that such a cask would be far from optimized for this application with its 24-assembly capacity. The TN 24 D and its 28-assembly capacity could not work, because although the KKG fuel design is quite close to the Doel 3 NPP fuel, it is several decimeters longer.

Furthermore, measurements made on the TN 24 D after loading demonstrated that shielding performance of the cask was quite better than the calculated one, and so optimization was possible.

	TN 24 D	TN 24 XL	TN 24 DH	TN 24 XLH	TN 52 L	TN120	TN31
Fuel assembly	PWR 17 x 17	PWR 17 x 17	PWR 17 x 17	PWR 17 x 17	BWR 8 x 8	VVER 440	VVER 1000
Active length	12'	14'	12'	14'	12.5'	2,4 m	3,63 m
Number of assemblies	28	24	28	24	52	120	31
Cooling time (years)	8	8	7	7	2.5	6	12
Burnup (MWd/tU)	36 000	40 000	55 000	55 000	45 000	45 000	55 000
U_{235} enrichment	3.4 %	3.3 %	3.4 %	3.4 %	4.9 % max. (3.9 average)	4.3 %	4.6 %
Max. thermal power (kW)	20	23	37	37	57	32	35
Heavy metal weight (Mt.U)	13	13	13	13	9.5	14.4	15

Table 1: The TN 24 family

Fuel assembly	PWR 15 x 15
Active length	12' (3660 mm)
Overall length	4,296 mm
Cooling time (years)	10
Average Burnup (MWd/tU)	42,000
U_{235} enrichment	3.8 %

Table 2: KKG fuel characteristics

The custom design process

When Transnucléaire considered the equation, it decided to make full use of the flexibility of the TN 24 dual purpose cask family, so as to optimize the cask proposed to KKG. The result was the TN 24 G, a dual purpose cask designed to accommodate 37 spent fuel assemblies from KKG, or 16 tons of heavy metal.

What was the design process?

The basic premise was to use the well proven boron aluminum basket already in service in other TN 24 casks, in order to gain maximum compacity of the spent fuel array in the cask while conducting fuel decay heat to the body internal cavity surface. This basket design is made of H shaped profiles mechanically assembled that make up the wall partitions (figure 1).

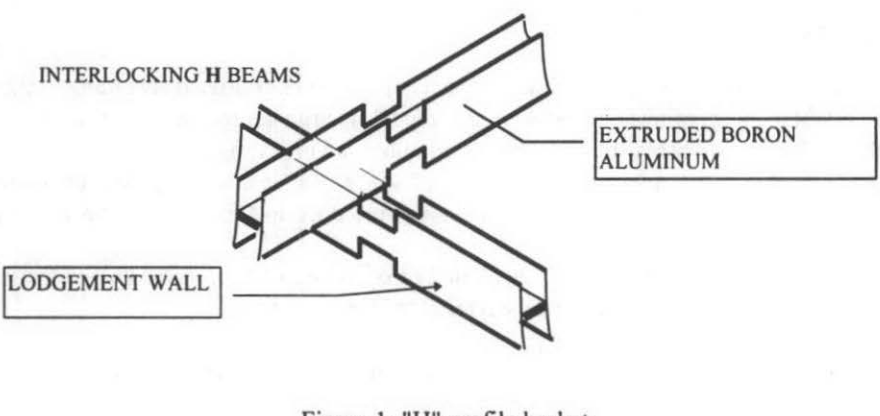

Figure 1: "H" profile basket

Considerations of criticality control and heat transfer thus yielded the minimum cavity size as a function of the number of fuel positions in the basket.
In parallel, shielding requirements, that are only slightly dependent on the quantity of spent fuel and much more on burnup and cooling time of spent fuel, were evaluated on the basis of transport regulations and of the ZWILAG specification. One of the key characteristics of the TN 24 family (1) is that it is possible to assess several balances between gamma shielding,

mainly stemming from the heavy forged steel body, and neutron shielding obtained with a proprietary resin poured in an annular space between a steel outer shell and the forged body.
This means that several couples of thicknesses of resin and of forging can solve the same shielding specification.

Ascertaining the limiting factors

It was now possible to evaluate possibilities and to confront them with the NPP limiting factors.
A first major limiting factor was the dimensions of the pool and of the access funnel through which the cask was to be lifted from ground level to loading area. From the drawings and also from careful observation on site, we found that squaring somewhat the usually cylindrical outer shape of the cask would allow to fit better. This was done, then, working backward, we deducted the needed shielding thicknesses from the maximum outer dimension to determine the maximum size of the cavity. Then we determined what baskets would fit in it depending on the gamma/neutron shielding balance.
Now came in the second major NPP limiting factor, mass: The heavy cask handling crane limited the cask weight to 119.4 tons. The thicker gamma shielding we would chose, the heavier the cask but also the smaller in size due to the reduction in thickness of the lower density neutron shielding resin!

From the bulk of the cask and the allowable outer transport dimensions the maximum dimensions of the transport shock absorbing covers were defined, and further analysis allowed for an evaluation of the g load under regulatory 9 meter drop test condition. This evaluation took into account the available crushing volume of shock absorbers. After several iterations, the TN 24 G was defined.

Major choices

There still were several solutions available, and Transnucléaire arbitrated according to the fact that a cask should strive to favor neutron shielding:" neutron sources decrease much slower than the gamma ones whereas the dose rates limitations are global figures.
It demonstrates that interim storage casks should tend to favor increasing neutron shielding rather than gamma shielding because in the long run, dose to the environment are mainly doses from the neutron source term.
In fact this may open possibility over the period of operation of an interim storage facility to admit more casks without increasing dose rates at the facility limits.

The resulting cask : The TN 24 G for 37 PWR spent fuel assemblies

When operated at the reactor cooling pool, with the only primary lid, the overall height of the cask is 4.9 m and it fits within a right prism with a square cross section except the trunnions which transversally protrude; then, when loaded its weight is 119 t. Forged carbon steel is used to manufacture the 3 main components making up the containment: thick shell, bottom, primary lid.
The containment system also provides the main gamma shielding: its thickness is dictated by shielding requirements and amply exceeds the needs of mechanical resistance. The thick shell is forged in a single piece, and the forged bottom is welded to it.

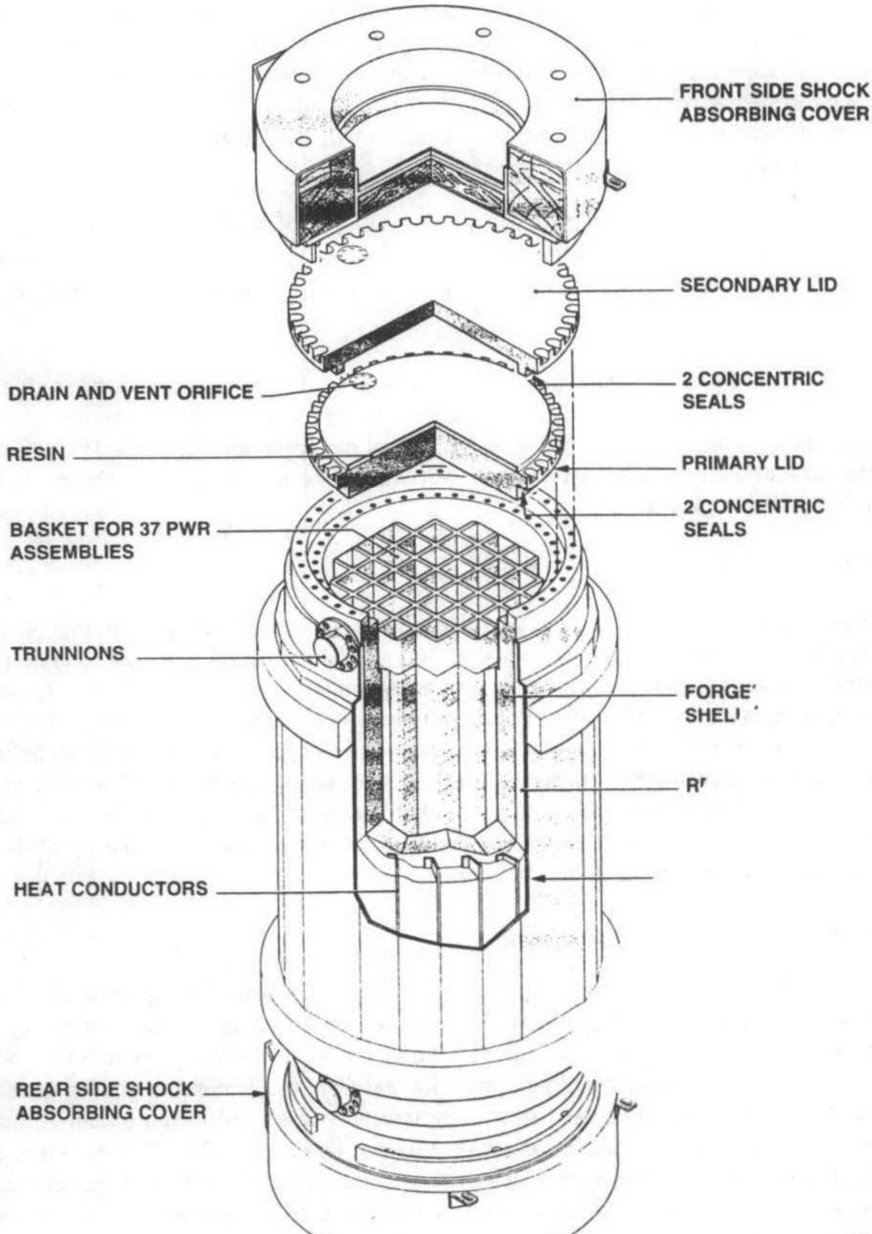

Figure 2: The TN 24 G cask

The carbon steel primary lid bolted to the upper end of the cask ensures the leaktightness of the cavity thanks to a checkable metallic gasket. The cask cavity wall is protected from corrosion by zinc-aluminum spray coating. The cask body is made from the above containment system surrounded by a layer of borated resin, up to 170 mm thick (depending on the radial orientation with respect to basket positions), acting as neutron shielding and enclosed within an external steel envelope.

Embedded in the resin, longitudinal copper plates connect the forged steel shell to the external envelope so as to transfer the decay heat from the fuel assemblies to the atmosphere. The cask is handled by means of two pairs of trunnions fixed at both extremities to the thick forged steel shell.

The primary lid is equipped with a single orifice allowing all the operations needed after the fuel assemblies have been loaded into the cask: draining water from the cavity, venting, drying, pumping vacuum and backfilling with a neutral gas (generally Helium). This orifice is connected to a draining tube reaching the lowest part of the cavity. Its leaktightness is also ensured by a metallic gasket.

Present Status of the cask

Successful drop tests on a one third model of the cask demonstrated during the month of April 1997 the ability of the TN 24 G to pass the transport regulatory tests. The cask also underwent successfully a test of high speed impact of a missile simulating the impact of a fighter jet in order to demonstrate compatibility with Zwilag requirements against accidents: no leak was detected after the impact. For that purpose, the cask was equipped with a metal "crash helmet" that protects its closure system. Meanwhile the casks are being manufactured and delivery is scheduled end of 1998. The licensing process is being carried on with the French competent Authority in terms of B(U) F licensing and with the Swiss competent Authority HSK for transport license validation and storage licensing.

Conclusions

The TN 24 G shows how Transnucléaire's design of the TN 24 family using boron aluminum baskets, heavy carbon steel forging as structural body and main gamma shielding, its proprietary resin for neutron shielding allow to tailor a cask to the specific conditions of an operator. The operator benefits from the experience and from the demonstrated level of safety stemming from more that 120 forged steel body transport casks and of more than 100 dual purpose and storage casks in the 100 ton range delivered by or ordered to Transnucléaire and its affiliates companies. By the optimization, and despite a limited number of specific units, the operator also contributes lower doses to its workers and to the environment, and reduces the number of transport operations required for delivering the casks to the intermediate storage facility.

References

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